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# Which sea ice models does the climate community need?

François Massonnet



# Which sea ice models does the climate community need?



## A few remarks!

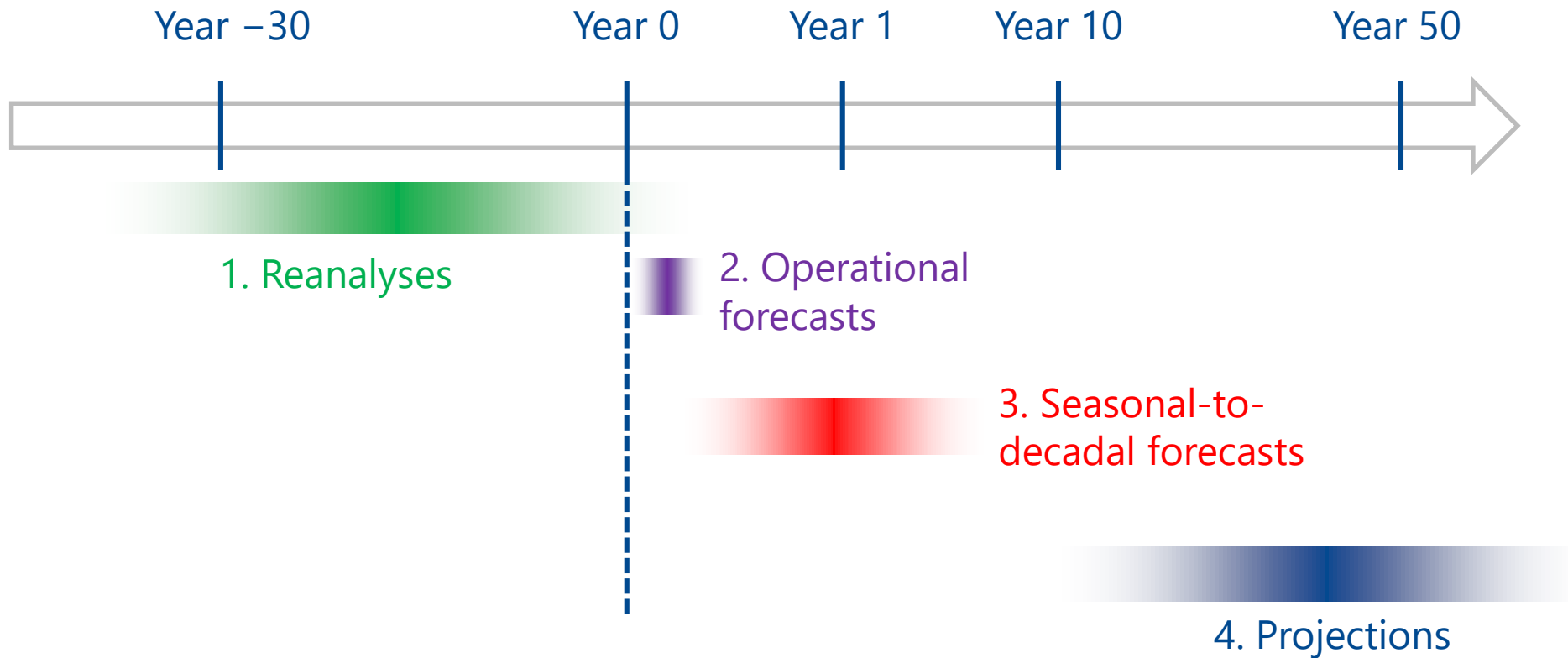
- This presentation is oriented towards *climate* aspects
  - Less emphasis on process aspects
  - Complementary to A. Barthélemy's, C. Rousset's and D. Salas's presentations
- This presentation is certainly not exhaustive
  - I have tried to be unbiased but may have missed important aspects
  - I'm happy to receive feedback and hear others opinions
- I'm highlighting several articles that I recommend reading if you haven't already done so

francois.massonnet@bsc.es

# Which sea ice models does the climate community need?



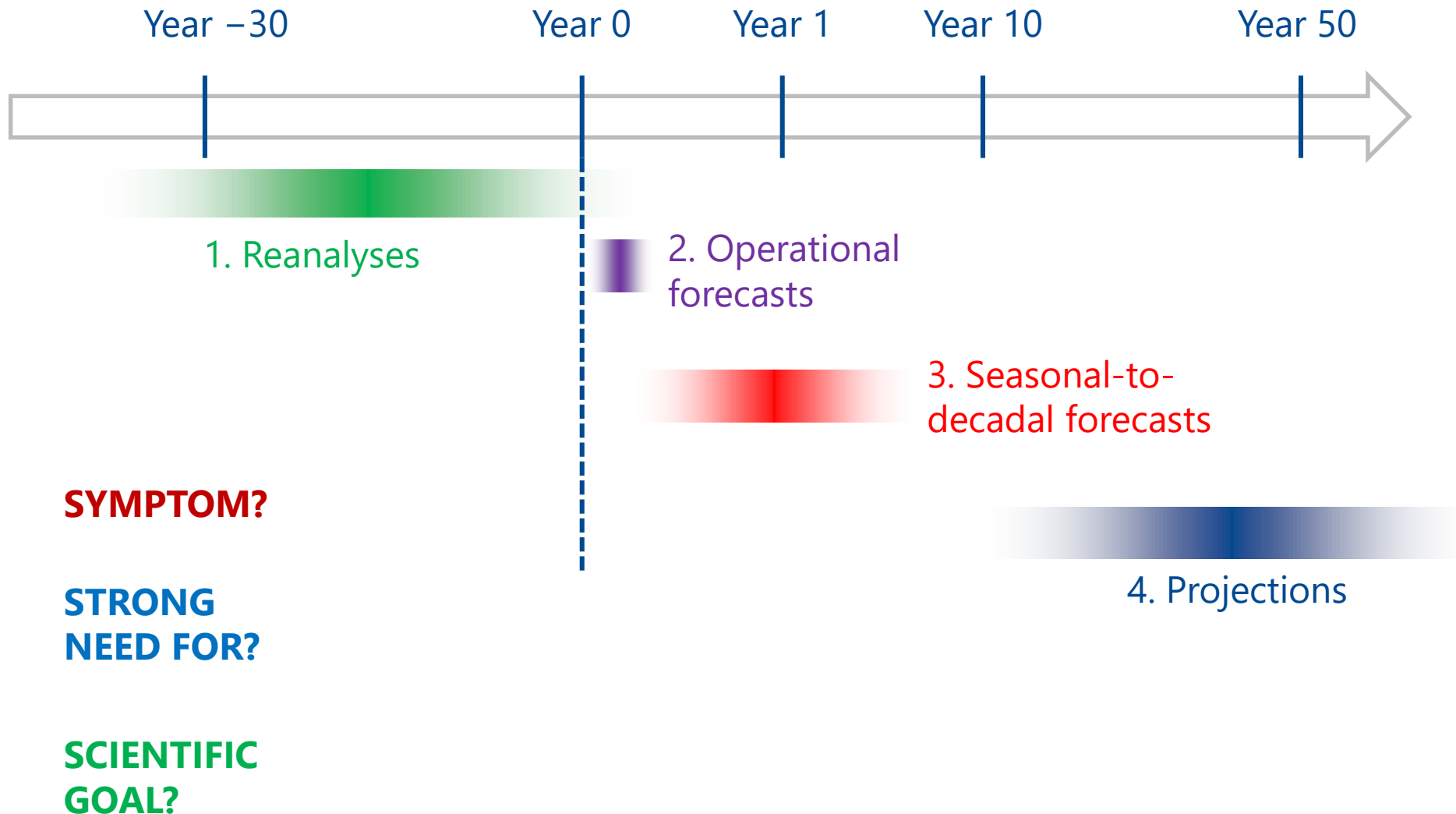
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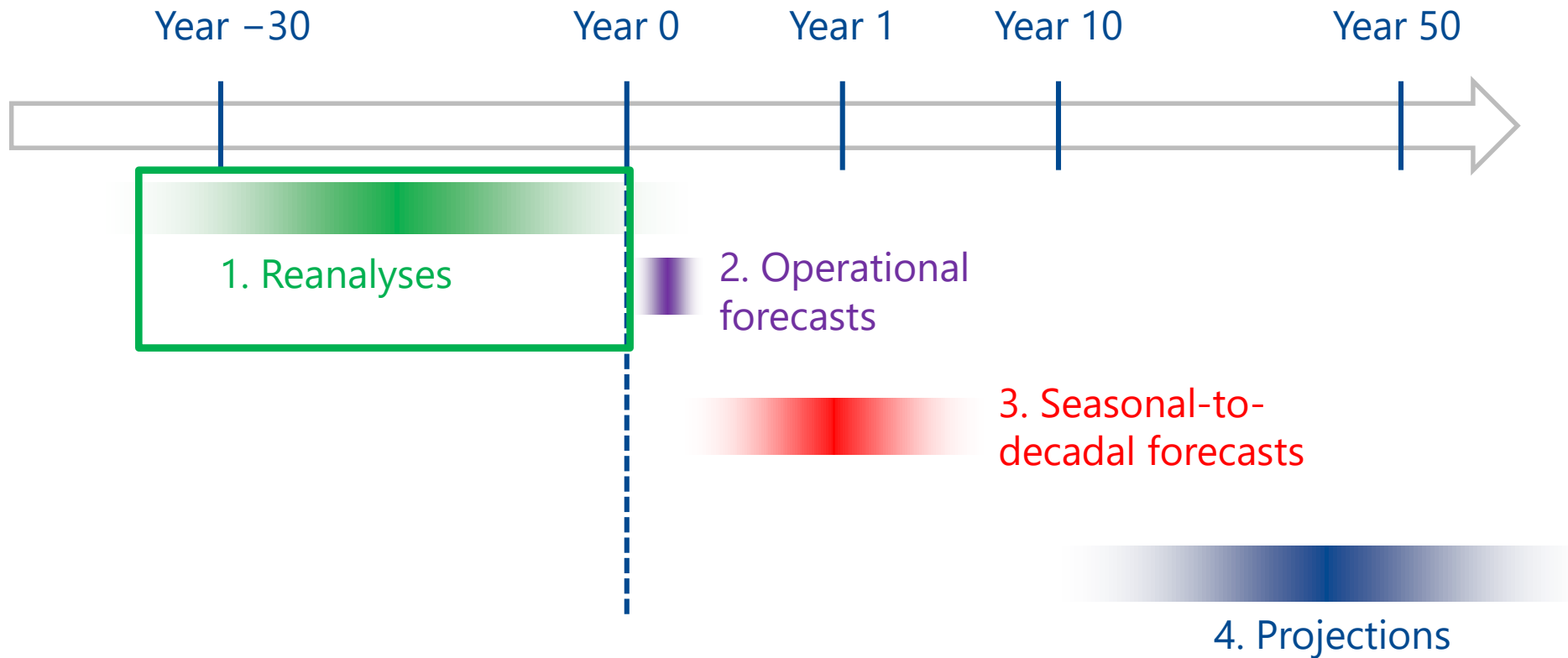
# Which sea ice models does the climate community need?



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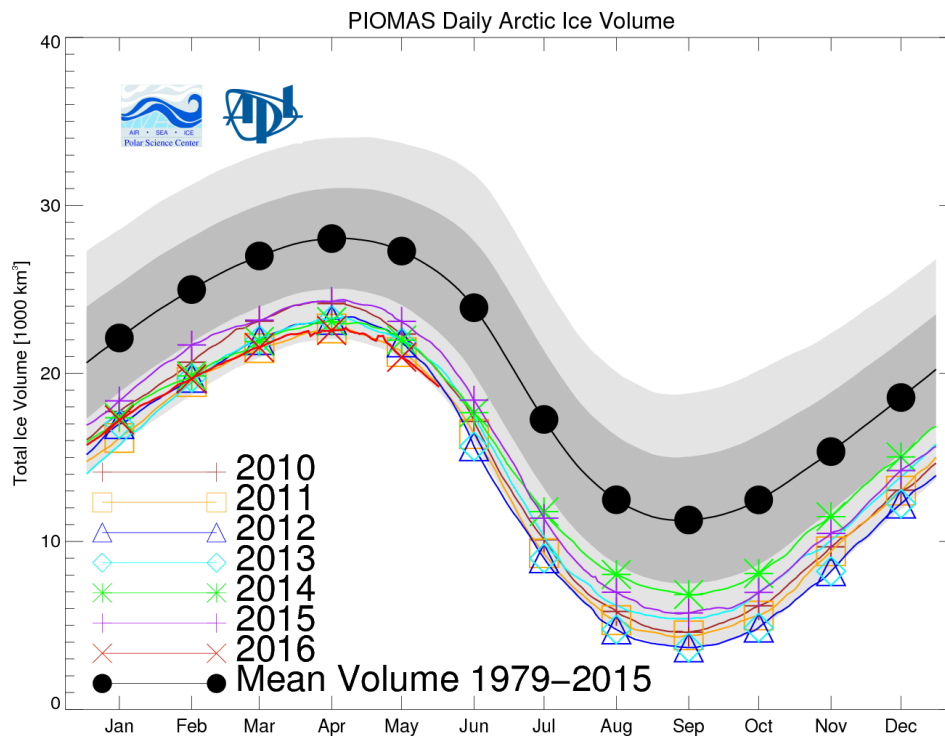


# Which sea ice models does the climate community need?



# 1. Reanalyses

**SYMPTOM** - The sea ice climate community is largely PIOMAS-dependent



<http://psc.apl.uw.edu/research/projects/arctic-sea-ice-volume-anomaly/>

# 1. Reanalyses



## SYMPTOM

- The sea ice climate community is largely PIOMAS-dependent

## STRONG NEED FOR

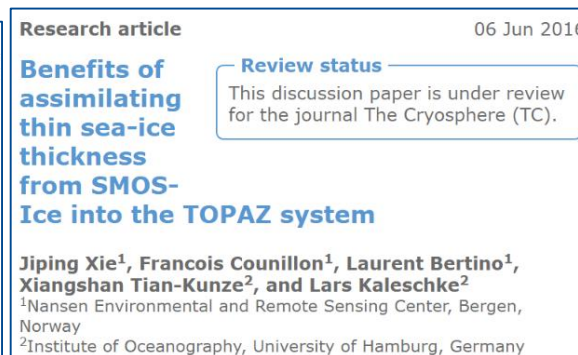
- Coupled and physically consistent polar reanalyses (ocean + ice + atmosphere; balanced)
- Assimilation of recent products (e.g., ESA-SICCI; SMOS)
- Quantification of uncertainty

## SCIENTIFIC GOAL

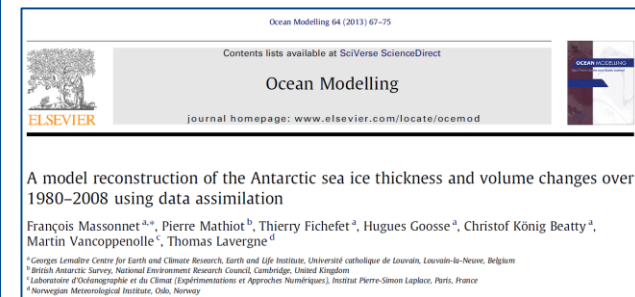
- Quantification of recent Arctic and Antarctic sea ice mass & energy balances with their uncertainties



Chevallier et al., Clim. Dyn., 2016

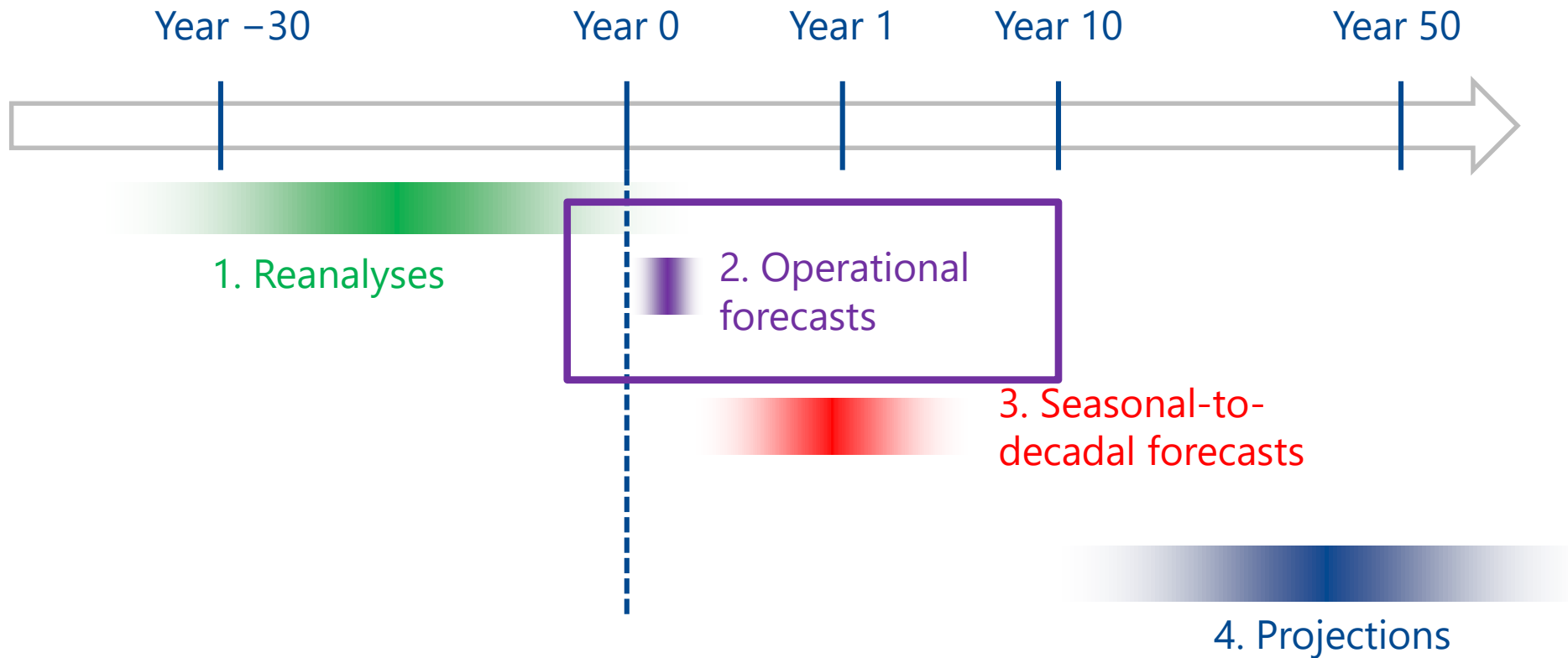


Xie et al., The Cryosph. Discuss., 2016



Massonnet et al., Oc. Modell., 2013

# Which sea ice models does the climate community need?

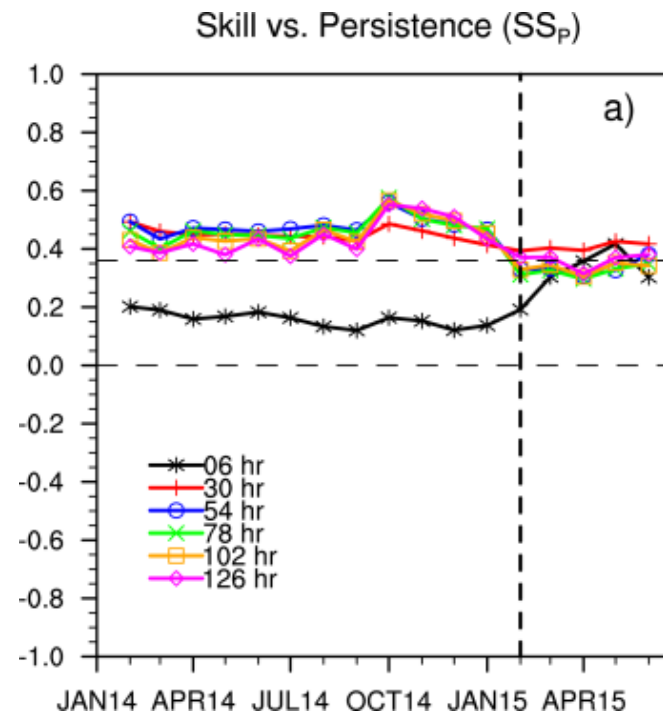




## 2. Operational forecasts

### SYMPTOM

- The community is using verification metrics that are useful to track performance, but often meaningless to end-users.



Hebert et al., JGR, 2015

## 2. Operational forecasts

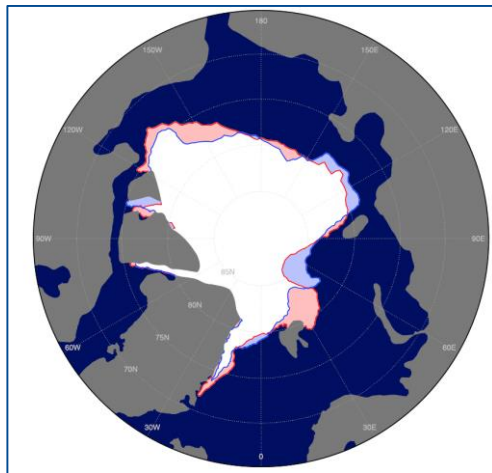


### SYMPTOM

- The community is using verification metrics that are useful to track performance, but often meaningless to end-users.

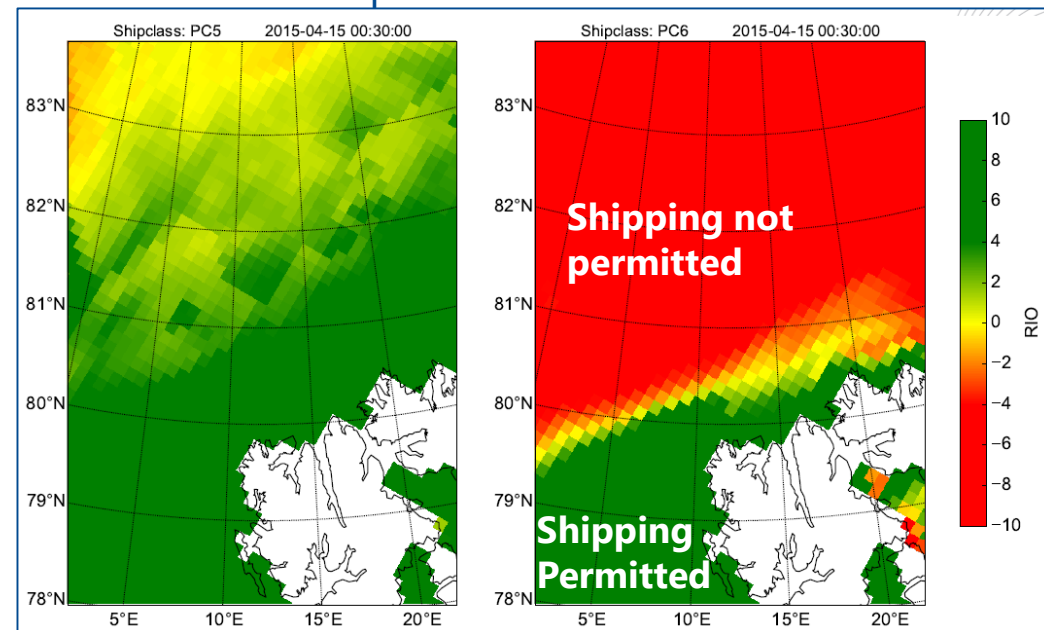
### STRONG NEED FOR

- Simple verification metrics for ice edge mismatch
- User-oriented diagnostics
- Probabilistic and risk information (incl. ice-thickness distribution)



Error = **OVERESIMATION** +  
**UNDERESTIMATION**

### Maps of risk index outcome



## 2. Operational forecasts



### **SYMPTOM**

- The community is using verification metrics that are useful to track performance, but often meaningless to end-users.

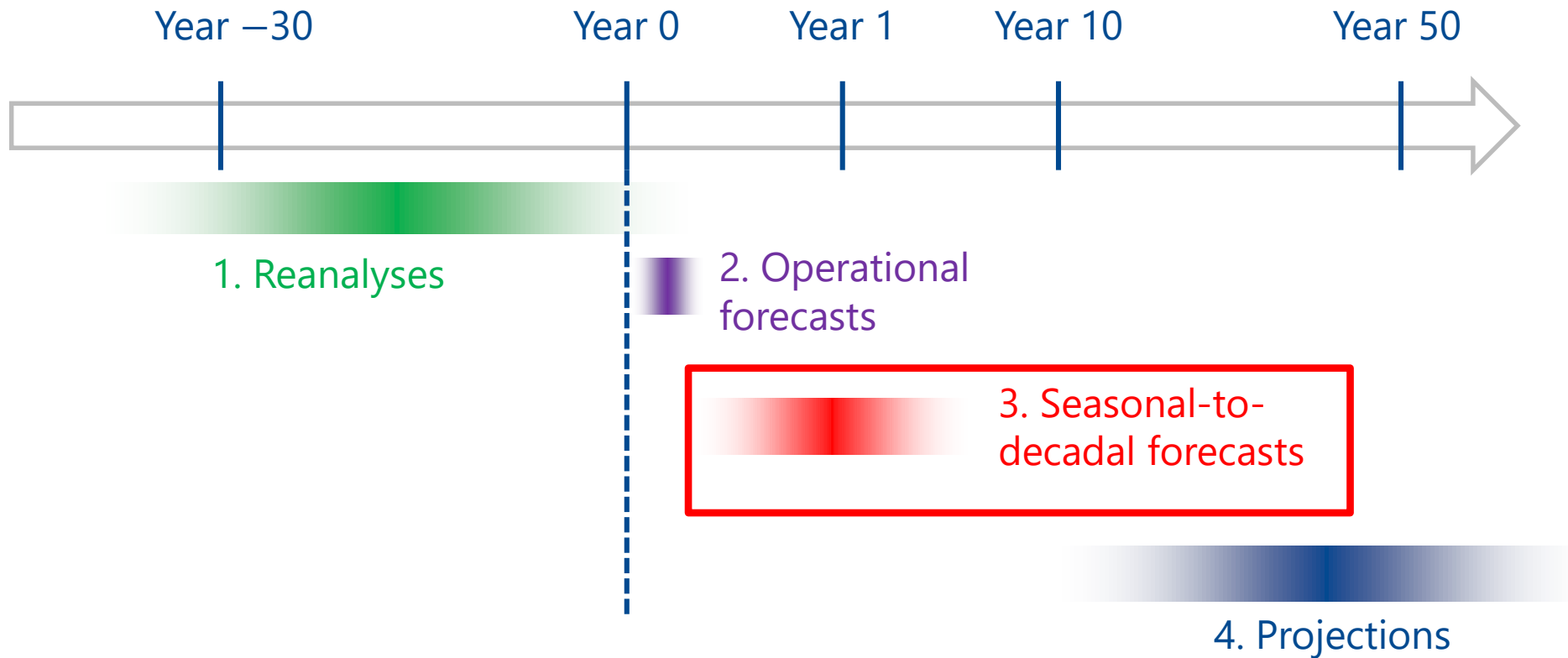
### **STRONG NEED FOR**

- Simple verification metrics for ice edge mismatch
- User-oriented diagnostics
- Probabilistic and risk information (incl. ice-thickness distribution)

### **SCIENTIFIC GOALS**

- Achievement of skillful forecasts beyond the academic beauty
- Usefulnes for upcoming campaigns (e.g., Year of Polar Prediction)
- Southern Ocean

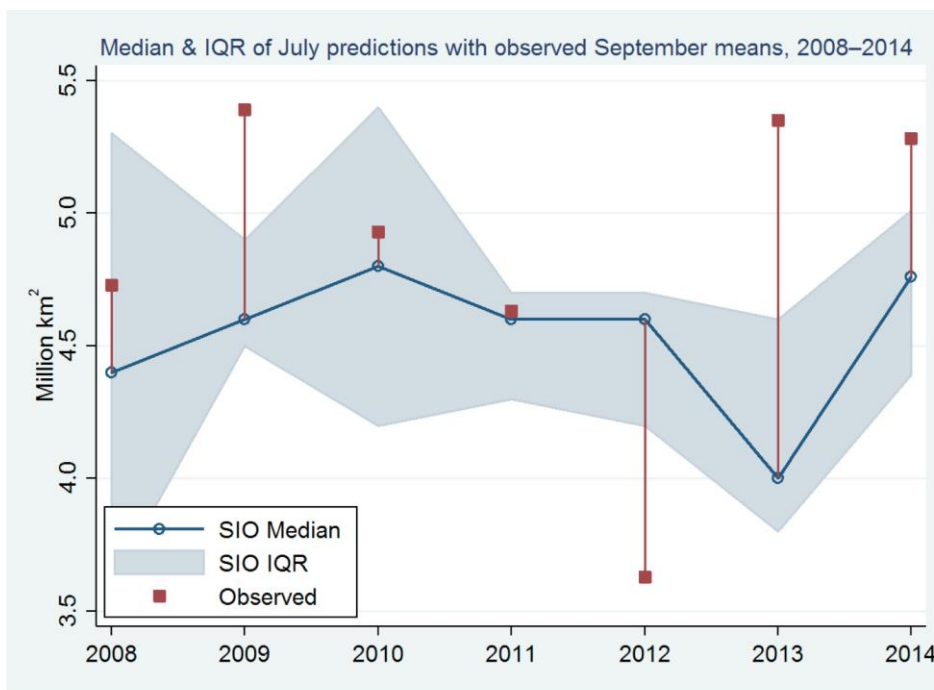
# Which sea ice models does the climate community need?



# 3. Seasonal-to-decadal forecasts

## SYMPTOM

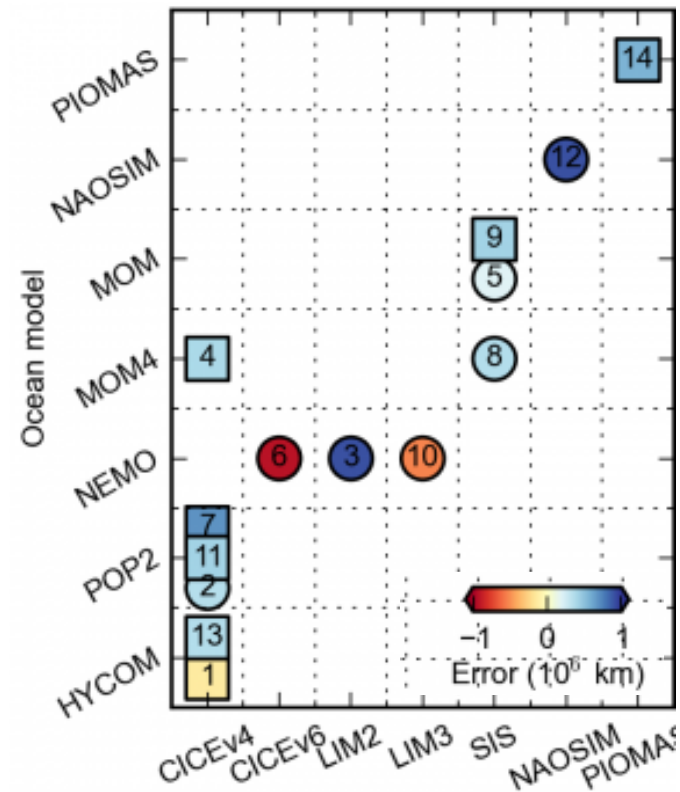
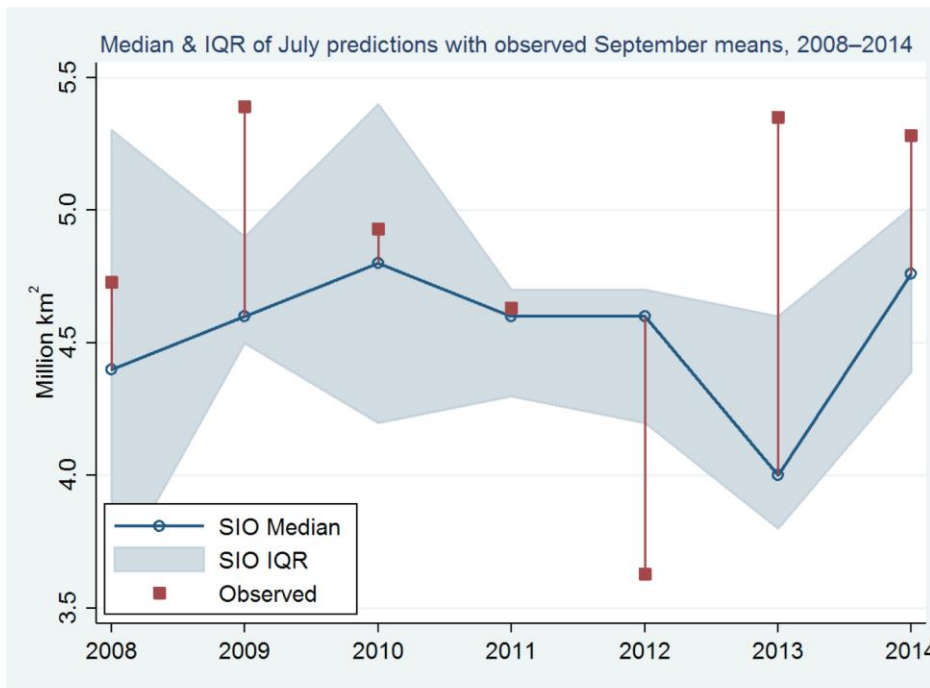
- Model and initial-condition uncertainty is not (enough) accounted for in current sea ice predictions



# 3. Seasonal-to-decadal forecasts

## SYMPTOM

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# 3. Seasonal-to-decadal forecasts

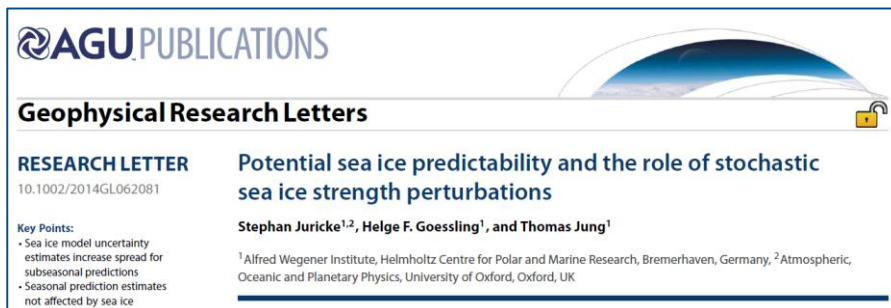


## SYMPTOM

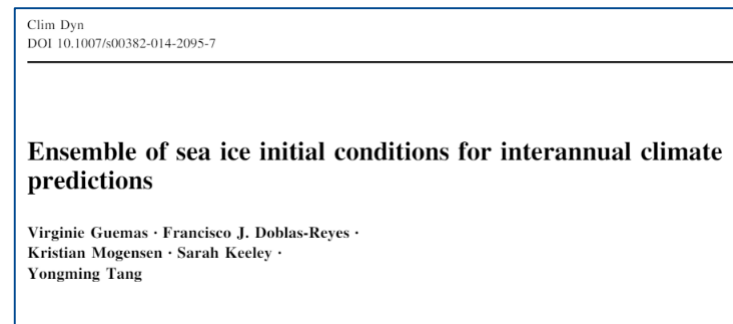
- Model and initial-condition uncertainty is not (enough) accounted for in current sea ice predictions

## STRONG NEED FOR

- Modular sea ice models with « switchable » features to test the impact of individual physical formulations on skill
- Stochastic formulations to reflect uncertainty in parameterizations
- Ensembles of sea ice initial conditions



Juricke et al., GRL, 2014



Guemas et al., Clim. Dyn., 2014

# 3. Seasonal-to-decadal forecasts



## SYMPTOM

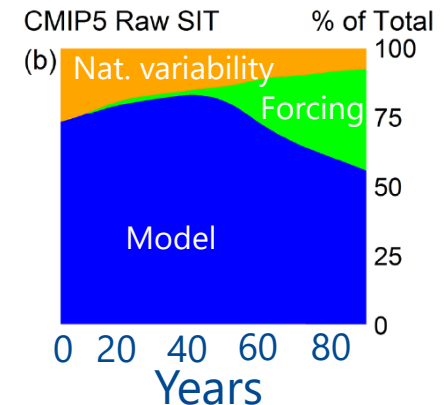
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## STRONG NEED FOR

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## SCIENTIFIC GOALS

- Link between potential and actual skill
- Budget analysis of uncertainty

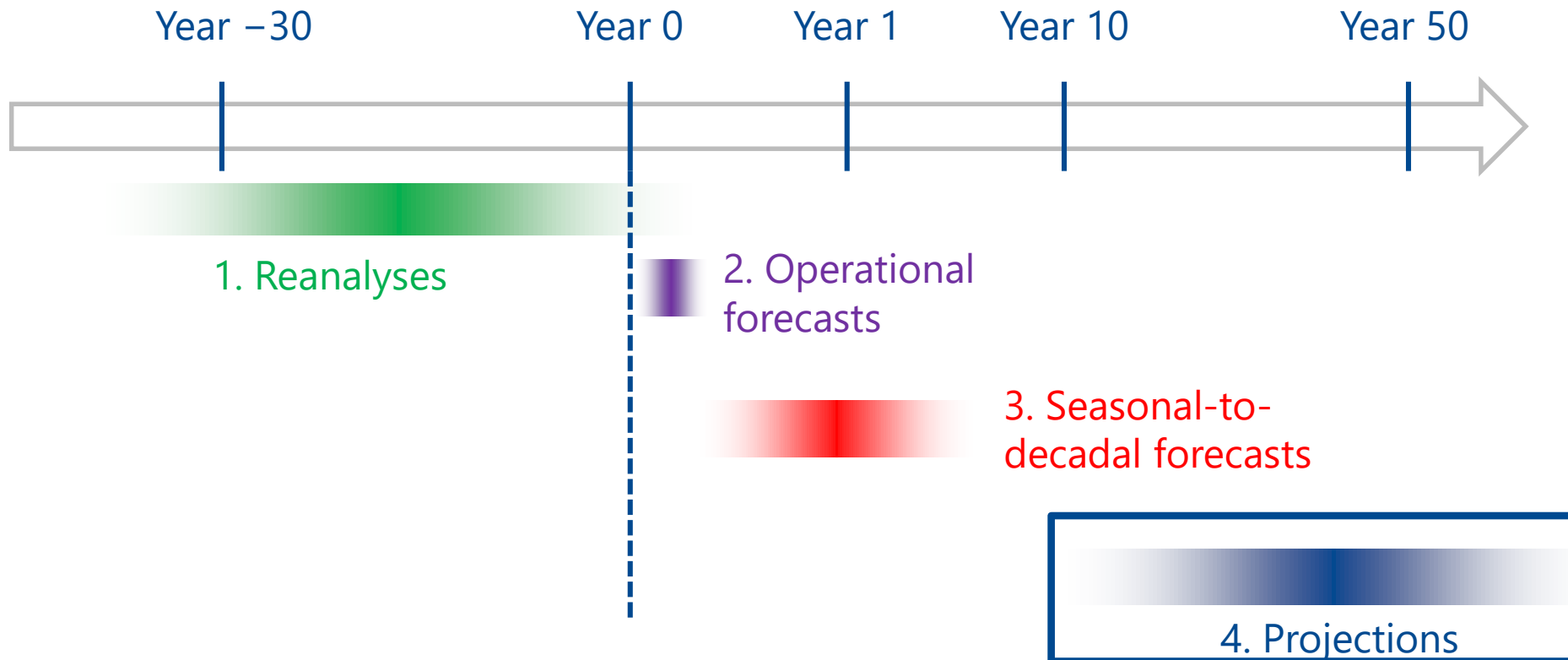




# Which sea ice models does the climate community need?



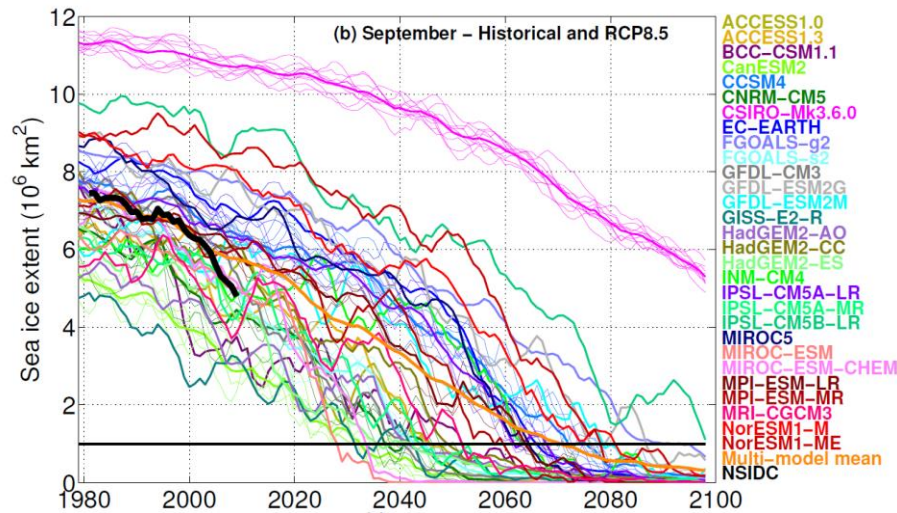
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# 4. Projections

## SYMPTOM

- Sea ice model response to external forcing is poorly understood in terms of baseline mean state



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## SYMPTOM

- Sea ice model response to external forcing is poorly understood in terms of baseline mean state

## STRONG NEED FOR

- Emergent constraints: link between present-day simulation of processes and long-term response

Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-67, 2016  
Manuscript under review for journal Geosci. Model Dev.  
Published: 13 April 2016  
© Author(s) 2016. CC-BY 3.0 License.



### Sea Ice Model Intercomparison Project (SIMIP): Understanding sea ice through climate-model simulations

Dirk Notz<sup>1</sup>, Alexandra Jahn<sup>2</sup>, Marika Holland<sup>3</sup>, Elizabeth Hunke<sup>4</sup>, François Massonnet<sup>5,6</sup>, Julianne Stroeve<sup>7,8</sup>, Bruno Tremblay<sup>9</sup>, and Martin Vancoppenolle<sup>10</sup>

### On the Robustness of Emergent Constraints Used in Multimodel Climate Change Projections of Arctic Warming

THOMAS J. BRACEGIRDLE

*British Antarctic Survey, Cambridge, United Kingdom*

DAVID B. STEPHENSON

*Mathematics Research Institute, University of Exeter, Exeter, United Kingdom*

(Manuscript received 31 July 2012, in final form 3 November 2012)

ABSTRACT

Bracegirdle and Stephenson, J. Clim., 2012

# 4. Projections



## **SYMPTOM**

- Sea ice model response to external forcing is poorly understood in terms of baseline mean state

## **STRONG NEED FOR**

- Emergent constraints: link between present-day simulation of processes and long-term response

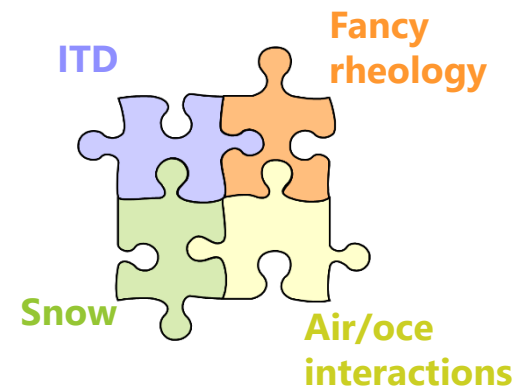
## **SCIENTIFIC GOALS**

- Better characterization of uncertainty and its sources
- Understanding the role of model physics on response to external forcing

## WHICH SEA ICE MODELS DOES THE CLIMATE COMMUNITY NEED?

### MODULAR MODELS

- Even if they look different, sea ice models are often very similar
- We need advanced, but modular sea ice models: a (European?) kernel + plug-and-play routines



### UNCERTAIN MODELS

- Reconstructions/predictions/projections are generally over-confident (under-dispersive)
- Formulations must be inherently probabilistic to reflect what we truly ignore (forcing, initial conditions, physics)



### INFORMATIVE MODELS

- Current sea ice models have plenty of information that is under-used!
- Packaging the information appropriately for the right user is a task whose difficulty is often underestimated





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# Thank you!

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